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16 Aug 1965, per document marking

(8)

14th Part of Report
No. AAEE/936

B

MINISTRY OF AVIATION

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

ARGOSY C. MK. 1 XR 105

EFFECT OF EXTERNAL STORES ON RADIO PERFORMANCE [C]

PRESENTED BY

W. MEDLAND
NAVIGATION AND RADIO DIVISION

A.E.E./936-PJ - 14

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT
BOSCOMBE DOWN

16. AUG. 65,
19 p.

Argosy C. Mk. 1 XR 105

Effect of External Stores on Radio Performance [C-NHAL]

W. Medland.
Navigation and Radio Division

A. & A.E.E. Ref: ANR 3A/03
H.Q. Ref: D.L.R.D.(A) AL.10
Period of Trials: September 1963 - November 1964

Summary

Radio trials have been carried out to determine the effect of externally carried stores on the performance of radio equipment in Argosy aircraft. 1,000 lb. bombs incorporating tail unit 107 were chosen as representing the worst interference case.

The only installation affected was the No. 2 V.H.F. but the performance was still within acceptable limits.

During these trials it was found that the I.F.F. Mk. 10 R.F. feeder cables were unusually long. It is recommended that the possibility of shortening these cables or otherwise achieving lower electrical loss be investigated.

This report is issued with the authority of

Air Commodore,
Commandant, A. & A.E.E.

(001 257)

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/1. Introduction ...

1. Introduction

Radio trials were requested by D.L.R.D.(A) AL.10B to determine the effect of externally carried stores on the performance of radio equipment. Argosy C. Mk. 1 XR 105 was used for these trials, which were carried out during suitable periods in parallel with the Armament Division trials.

2. Radio Reports

2.1 Previously Issued

2nd Part of Report No. AAEE/936
Radio Acceptance Trials (Complete Fit)

2.2 Included Herewith

Trials to determine effect on radio equipment performance when external stores are carried.

2.3 To Follow

The effect on radio equipment performance with in-flight refuelling probe fitted.

Auto-land trials covering A.R.I. 23063 (Leader Cable) and A.R.I. 23061 Alt. Mk. 7 installations.

3. Trials Method

The aircraft was fitted with six stores carrying racks mounted low on the sides of the fuselage, three on each side and approximately equally spaced along the length of the aircraft (see Fig. 2). The position of these racks was such that the stores carried were level with most aerials on the underside of the aircraft and might, therefore, modify the polar diagrams of the following aerials:-

Elliott V.H.F.	-	No. 2 aerial
U.H.F.	-	lower aerial
I.F.F. 10	-	lower aerial
Rebecca Mk. 4	-	transmitter and O/R aerials

In the case of Rebecca Mk. 4 the effect would be to reduce side aspect cover. A.L.10 stated that the requirement for the Omni-range aerial had been cancelled and thus side aspect cover is of little importance. Trials were not, therefore, carried out on this installation.

The effect of external stores on the polar diagrams of the other aerials was determined by obtaining polar diagrams of the aerials with a full load of stores carried and comparing these with equivalent polar diagrams obtained on a 'clean' aircraft during the initial acceptance trials. For comparison each polar diagram was plotted to an arbitrary reference level which gave reasonable agreement between both polar diagrams over most of the azimuth angles so that small differences were more readily apparent.

Wherever a significant difference between the two polar diagrams was apparent the range performance of the installation on that aspect was investigated.

It was considered possible that reflections from the stores might affect the performance of Violet Picture either by introducing areas of reversed indication or by introducing a squint error when an asymmetric load was carried. Tests for these effects were carried out.

/Proximity ...

Proximity of stores to the A.D.F. sense aerials might be expected to reduce the sensitivity of the system while the large mass of metal might affect the accuracy. Tests were designed to investigate these possibilities.

No attention was paid to the possibility of inadvertent operation of fuzing devices etc. in the bombs from radio-transmissions.

The stores racks are intended for carriage of bombs of different sizes and types, and sponson bundles, which may be of a number of sizes and carry a wide range of contents. In order to standardise on a realistic 'worst load' it was decided to carry out the trials with a full load of 1,000 lb. bombs (which are the heaviest type likely to be carried) with tail units type 107 (which are the longest likely to be carried). It must be assumed that smaller bombs would have less effect, and that sponson bundles are unlikely to have more effect on the aerial performance in each case.

4. A.R.I. 23088 - Elliott V.H.F.

4.1 Details of the Installation

The aircraft was fitted with a dual installation of Elliott V.H.F. The aerial for No. 1 V.H.F. was on the cockpit roof and will not be affected by external stores. The aerial for No. 2 V.H.F. was on the underside of the fuselage at approximately the same height as the bombs and lying level with the space between the centre and rear bombs on the port side.

4.2 Flight Trials

With the aircraft carrying six 1,000 lb. bombs polar diagrams were obtained on No. 2 V.H.F. aerial by flying the aircraft in an orbit about a point 75 n.m. from Boscombe Down. The aircraft was levelled out at each 10° change of heading while a short transmission was made, signal strength measurements being taken at the ground station. Corrections for the variation of signal strength with the range were applied from the results of a special calibration flight across the diameter of the orbit. The trials frequencies were 118.8 Mc/s. and 132.0 Mc/s. and the trial was carried out at 8,000 ft.

The results of these trials are shown at Figs. 3 - 4 with the polar diagrams obtained during the initial C.A. release trials in Argosy C. 1 XN 816 and published in 2nd Part of Report No. AAEE/936 superimposed for comparison. These results show that the Aerial Polar Diagram has been modified by the stores at each frequency.

Range checks were carried out (at 8,000 feet) to determine the performance of the installation on the poor aspects. The results of these trials are shown below:-

Frequency	Aspect	Range	Comments
118.8 Mc/s.	360°	120 n.m.	2 way contact
"	180°	120 n.m.	" " "
"	265°	97 n.m.	" " "
"	072°	92 n.m.	" " "
132.0 Mc/s.	360°	110 n.m.	2 way contact
"	180°	105 n.m.	" " "
"	222°	98 n.m.	" " "
"	091°	91 n.m.	" " " (str. 2)
"	037°	87 n.m.	" " " (str. 2)

/The minimum ...

The minimum range normally accepted at this altitude is 92 n.m., therefore these results are considered satisfactory.

5. A.R.I. 18124/1 - U.H.F.

5.1 Details of the Installation

The lower U.H.F. aerial was on the underside of the fuselage on the starboard side at approximately the same height as the bombs and level with the space between the centre and rear bombs.

5.2 Flight Trials

With six 1,000 lb. bombs attached, polar diagrams were obtained on the lower aerial by flying the aircraft in orbits about a point 40 n.m. from Boscombe Down. The aircraft was levelled out at each 10° change of heading while a short transmission was made. Signal strength measurements were taken at the ground station. Corrections for the variation of signal strength with range were applied from the results of a special calibration flight across the diameter of each orbit. The trials frequencies were 236.1 Mc/s., 305.5 Mc/s. and 395.8 Mc/s.

The results of these trials are shown at Figs. 5 - 7 with the polar diagrams obtained during the initial C.A. release trials on Argosy C. 1 XN 816 and published in 2nd Part of Report No. AAEE/936 superimposed for comparison. These show a general agreement though 'holes' at the following aspects may be due to the external stores:-

At frequency 236.1 Mc/s. - 300° and 090°
" " 305.5 Mc/s. - 080°, 155° and 225°
" " 395.8 Mc/s. - 260°

Other 'holes' which occurred when stores were carried coincide with already existing 'holes' on the 'clean' aircraft.

Range checks were carried out at 8,000 feet to investigate the performance of the installation on these poor aspects. The results are shown below. Worst aspects at each frequency were:-

At 236.1 Mc/s. - Aspect 300° which gave strength "2" reception on the ground at 85 n.m.

At 305.5 Mc/s. - Aspect 225° which gave strength "2" to "3" reception on the ground at 85 n.m.

At 395.8 Mc/s. - No aspect was significantly poorer than the head and tail aspects.

The limiting ranges obtained on the head and tail aspects were:-

Frequency (Mc/s.)	Limiting Range (n.m.)	
	Inbound	Outbound
236.1	100	100
305.5	100	105
395.8	95	95

All these results are considered acceptable.

/6. ...

6. A.R.I. 18120/6 - Violet Picture

6.1 Details of the Installation

The Violet Picture aerials were under the fuselage forward of the nose-wheel and at approximately the same height as the bombs. It was considered possible that interference between the direct signal and signals reflected from the bombs might result in squint or reversals of steering information.

6.2 Flight Trials

With the aircraft carrying a full bomb load orbits were flown about a point approximately 20 n.m. from Boscombe Down using a 20 watt ground station and operating on frequencies of 236.1 Mc/s., 305.5 Mc/s. and 395.8 Mc/s. No areas of reversed indication were found.

The system was checked for squint errors using the three trials frequencies listed above with the following bomb loads:-

(i) A full load.

(ii) Three bombs all on one side of the aircraft.

The maximum squint error found was 5°. The maximum squint errors permitted in RIM 114 are:-

Ahead $\pm 15^{\circ}$
Astern $\pm 20^{\circ}$

The results obtained are therefore considered acceptable.

7. Radio Compass A.D. 712

7.1 Details of the Installation

The aircraft carried a dual A.D. 712 installation. Both loop aerials were on the underside of the fuselage near the centre line. Each sense aerial was near to one of the rear bombs. It was considered possible that the proximity of bomb and sense aerial might reduce range performance due to capacitive effects.

7.2 Flight Trials

Range checks were carried out against three N.D.Bs. on No. 2 A.D.F. The results are detailed below:-

Beacon	Frequency	Rated Range	Range Achieved
Strumble	249 Kc/s.	-	103 n.m.
Berry Head	318 Kc/s.	25 n.m.	77 n.m.
Woodley	723.5 Kc/s.	50 n.m.	113 n.m.

An air swing of No. 2 A.D.F. was carried out during the I.F.F. polar diagram trials. The results of this trial are shown at Fig. 8. This trial was carried out with the aircraft flying at 1,200 feet A.G.L. at a distance of 20 n.m. from the Beacon (Colerne 370 Kc/s.). It is thought that the proximity of the ground (which is particularly uneven in this region) caused the rather large spread of errors shown, but the overall result is within the acceptable limits of error which are $\pm 5^{\circ}$ and is considered acceptable.

/8. ...

8. A.R.I. 5848 - I.F.F. 10 with S.I.F.

8.1 Details of the Installation

The lower I.F.F. aerial was on the underside of the fuselage slightly to port of the centre line and level with the centre bombs.

8.2 Flight Trials

With the aircraft carrying a full load of 1,000 lb. bombs a polar diagram of the lower I.F.F. aerial was obtained. For this trial the aircraft was flown on courses varying in 10° intervals through 360° over a pinpoint 23 n.m. from Boscombe Down. Signal strength measurements were taken at the Ground Station as the aircraft crossed the pinpoint with the installation responding to ground interrogation.

Considerable difficulty was experienced in obtaining suitable results since the equipment frequently failed to respond to the interrogating signal. Suitable results were eventually obtained by using a directional aerial at the Ground Station. This result is shown at Fig. 9 together with the polar diagram obtained during the initial C.A. release trials on Argosy C.1 XN 816 superimposed for comparison. These results show no significant difference which may be attributed to the stores.

8.3 Points arising from this trial

An extensive examination of the installation was carried out in an attempt to improve the performance of the I.F.F. 10.

The first fault found was an exhausted dessicator in the aerial switch unit. This can lead to moisture deposits in the coaxial switch so that the theoretically open circuited aerial lead shunts the selected aerial causing mis-match and reduced transference of power. The complete switch unit was changed for a serviceable unit with fresh dessicant.

The aerial socket at the transponder had an enlarged engaging hole. The transponder was replaced by a unit with a serviceable socket.

The termination at the transponder end of the transponder-switch unit cable was loosely assembled (finger loose). This was remedied.

The losses of the aerial system were checked and though high were not considered sufficient to account for the extremely poor signal levels recorded at the Ground Station.

The symptoms experienced at the Ground Station suggested an intermittent fault, and it was found that gentle manipulation of the connections at the transponder end of the transponder-switch unit feeder cable could introduce this fault. Apparently the chief offender in this was a right angle adaptor type UG.221C/11 which attaches directly to the transponder. This item was removed, the feeder being directly attached to the transponder and the fault occurred rather less frequently (but still to an unacceptable extent). Though the termination mentioned above was apparently satisfactory at this time, a replacement feeder was fitted but no appreciable improvement resulted.

Further tests of cable losses revealed that an intermittent fault resulting in a sudden loss of 20 dB could occur. Further investigation was curtailed by the urgent need for re-allotment of the aircraft and the faulty component had not been identified.

/In ...

In the course of these investigations it was found that exceptionally long R.F. feeders are used in the Argosy aircraft. These are shown diagrammatically in Fig. 10. While the minimum length required to connect the lower aerial to the switch unit is not known the other cables appear unnecessarily long since the direct distance between the transponder and switch unit plugs is approximately 15 in., and 12 feet of feeder cable is used to join them, while the switch unit and upper aerial are approximately 6 feet apart and are connected by 32 ft. 6 in. of feeder cable.

The attenuation of Uniradio 67 cable at I.F.F.10 frequencies is approximately 8 dB/100 feet. Thus, neglecting the effect of mis-matches at discontinuities, the cable attenuation cannot be less than:-

$$\text{At the upper aerial } 12 + 32.5 \times \frac{8}{100} = 3.6 \text{ dB}$$

$$\text{At the lower aerial } 12 + 45 \times \frac{8}{100} = 4.6 \text{ dB}$$

Specification No. RRE X5312 states "The cable loss should not exceed 3 dB".

Consideration of the effect of mis-matches using the method detailed in R.R.E. Tech. Note No. 216 shows the maximum possible loss of system gain is:-

At the upper aerial - 5.9 dB

At the lower aerial - 6.5 dB both w.r.t. a matched isotropic source

Specification No. R.R.E. X5312 gives a limiting loss of 5 dB.

9. Conclusions

9.1 A.R.I. 23088 - Elliott V.H.F.

The polar diagram of No. 2 V.H.F. is altered when carrying 1,000 lb. bombs, but the range performance was satisfactory on all aspects at the frequencies and altitudes tried.

9.2 A.R.I. 18120/6 - Violet Picture

There was no evidence that the performance was in any way affected by carriage of external stores.

9.3 A.R.I. 18124/1 - U.H.F.

The polar diagram of the lower aerial was slightly modified by external stores but the range performance was still acceptable on all aspects.

9.4 Radio Compass A.D. 712

There was no evidence that the performance of this installation is degraded by external stores.

9.5 A.R.I. 5848 - I.F.F. 10

There was no evidence that the performance was affected in any way by the fitting of external stores.

The performance of the installation was however, not up to standard, this is due to the losses introduced by the long R.F. feeder vables (para. 8.3 refers).

/10. ...

10. Recommendations

10.1 A.R.I. 23088

The original C.A. release statement need not be changed for carriage of 1,000 lb. bombs. Other larger stores may degrade range performance on No. 2 V.H.F.

10.2 A.R.I. 18120/6

The original terms of C.A. release need not be amended for carriage of external stores.

10.3 A.R.I. 18124/1

The original terms of C.A. release need not be amended for carriage of external stores.

10.4 Radio Compass

The original terms of C.A. release need not be amended for carriage of external stores.

10.5 A.R.I. 5848 - I.F.F. 10

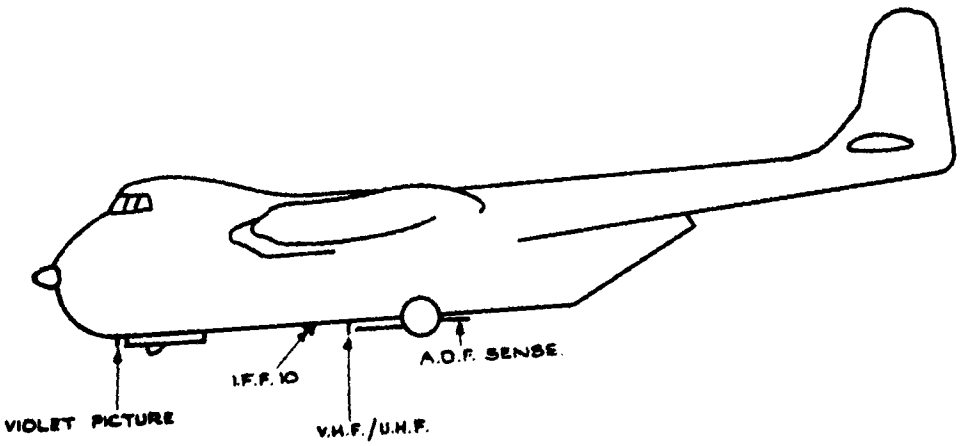
The original terms of C.A. release need not be amended for carriage of external stores.

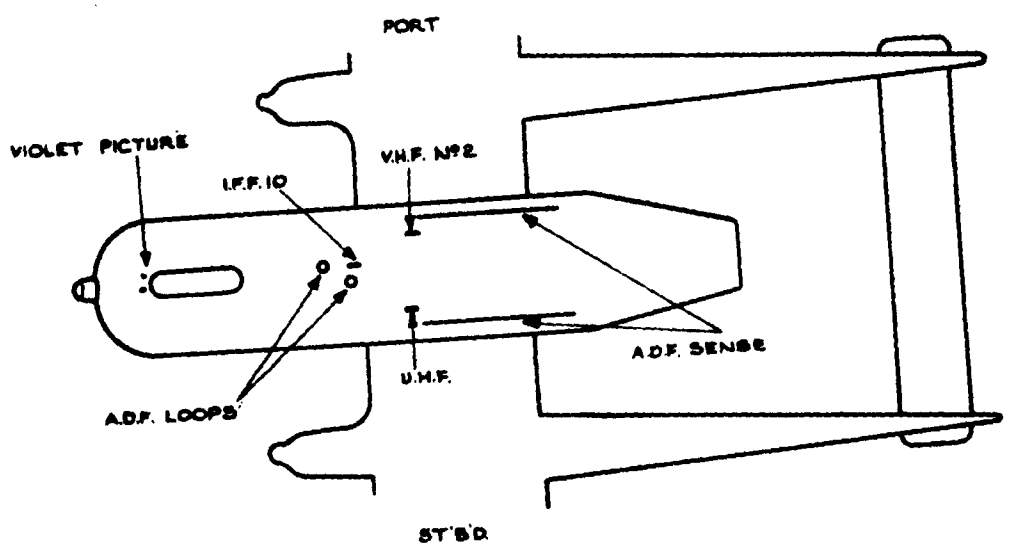
The possibility of reducing the lengths of any or all of the R.F. feeders or of incorporating lower attenuation cables should be investigated. The cause of the intermittent fault described in para. 8.3 should also be found since this may be common to all Argosy aircraft.

Circulation List

D.L.R.D.A./A.L.10	3 Copies 1 for Action
A.D.A.C.T.2	2 Copies (for information of D.P.O.)
A.C.(Q)	1 Copy
R.D.T. 3	1 Copy
T.I.L.	50 Copies
R.A.E. Farnborough	6 Copies
R.A.E. Bedford	2 Copies
R.T.O.(A) H.S.A. Woodford	2 Copies

FIG .1.



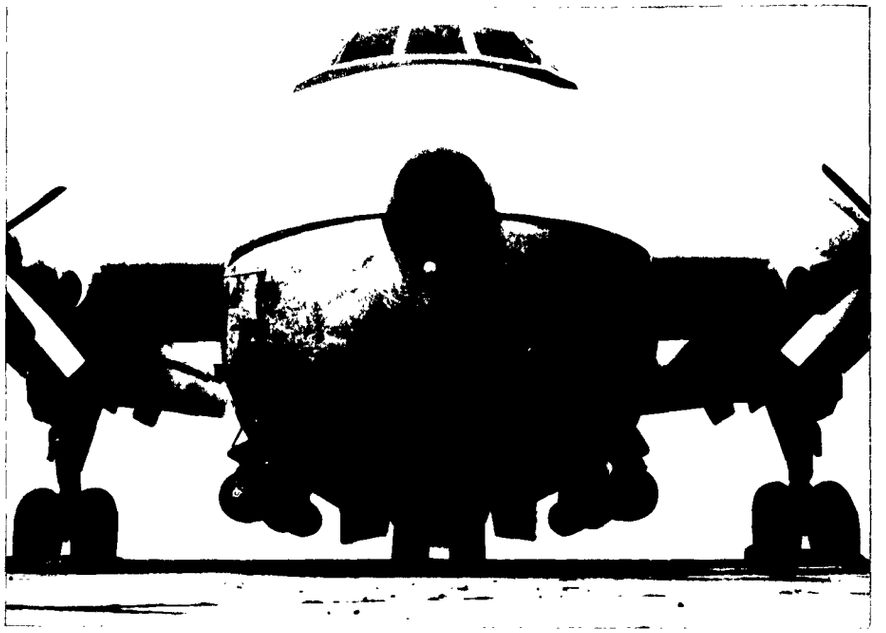


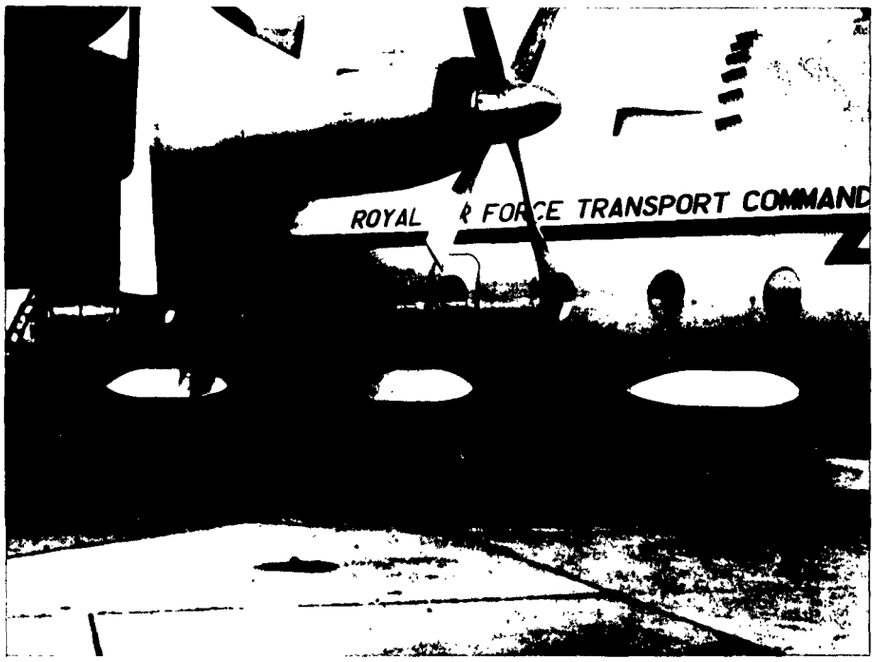
NOTE:- ONLY EQUIPMENT WHICH HAS BEEN TESTED IS SHOWN

(NOT TO SCALE)

DIAGRAMMATIC SKETCH OF AERIAL POSITIONS.

SKD 3456 | 14th PART OF REPORT Nos A.&A.E.E./938 | ARGOSY C.MK.1. XR106 & XN816 | TR S.J.H. | CH. MR WITHERS | APP. Kbl. for S of AR | 29.7.61



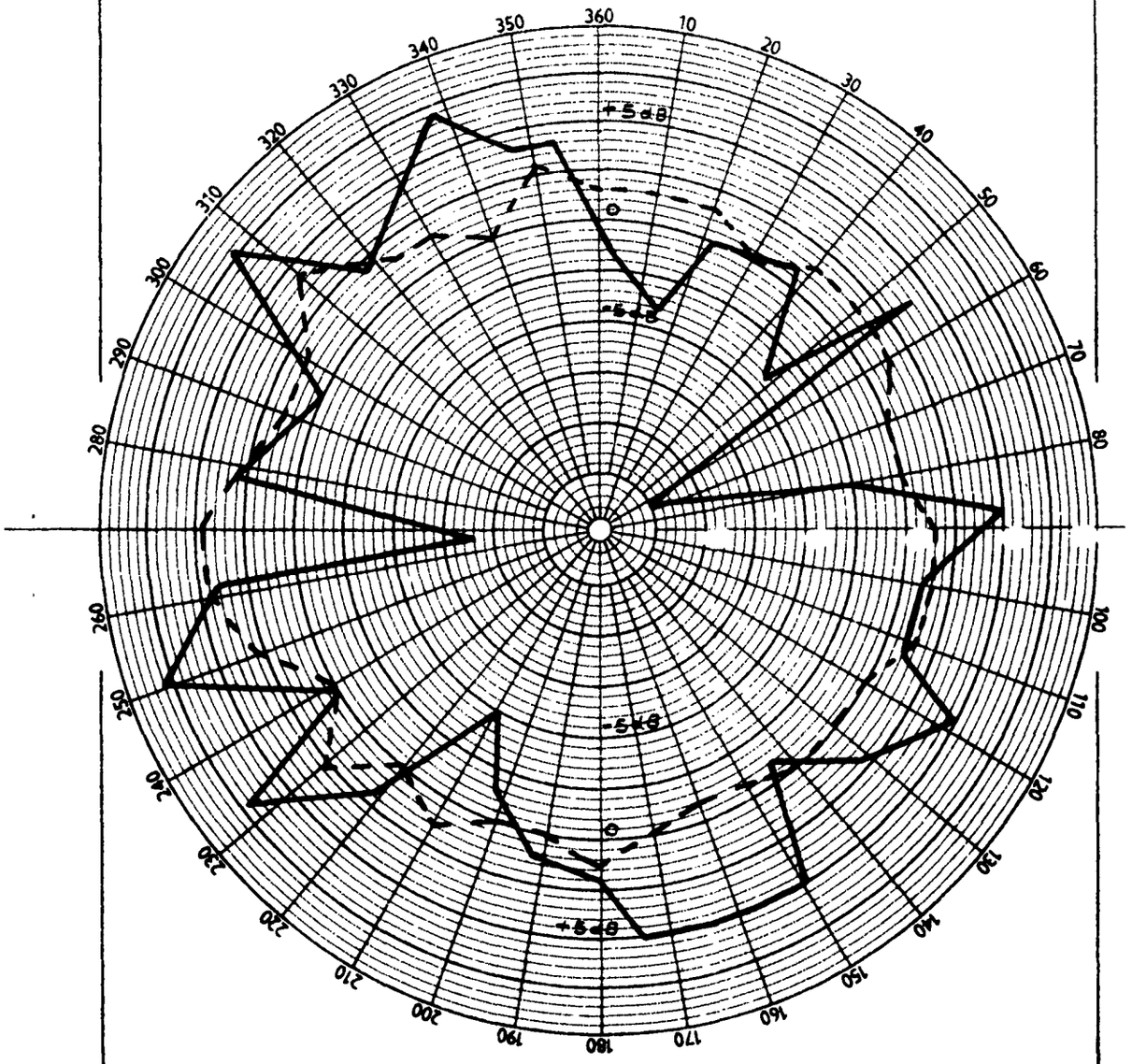


ARGOSY C. MK.1, XR 105, - CARRYING SIX(6) 1,000LB. BOMBS.
(THE LOWER PHOTOGRAPH SHOWS THE TYPE USED ON RADIO TRIALS).

FIGURE 2.

FIG. 3.

FREQUENCY:- 118·8 Mc/s.
DISTANCE FROM BASE:- XN 816 - 23 N.M., XR 105 - 75 N.M.
HEIGHT ABOVE BASE:- XN 816 - 2,000 FT., XR 105 - 8,000 FT.
AIRCRAFT:- TYPE:- ARGOSY C. MK. 1.
Nº: XR 105 & XN 816.
DATE:- XN 816 - 26·9·61, XR 105 - 2·1·64.
A.R.I:- 23088.



ARGOSY XR 105 CARRYING STORES.
ARGOSY XN 816 'CLEAN'.

EFFECT OF EXTERNAL STORES ON V.H.F. POLAR DIAGRAM (Nº. 2 V.H.F.)

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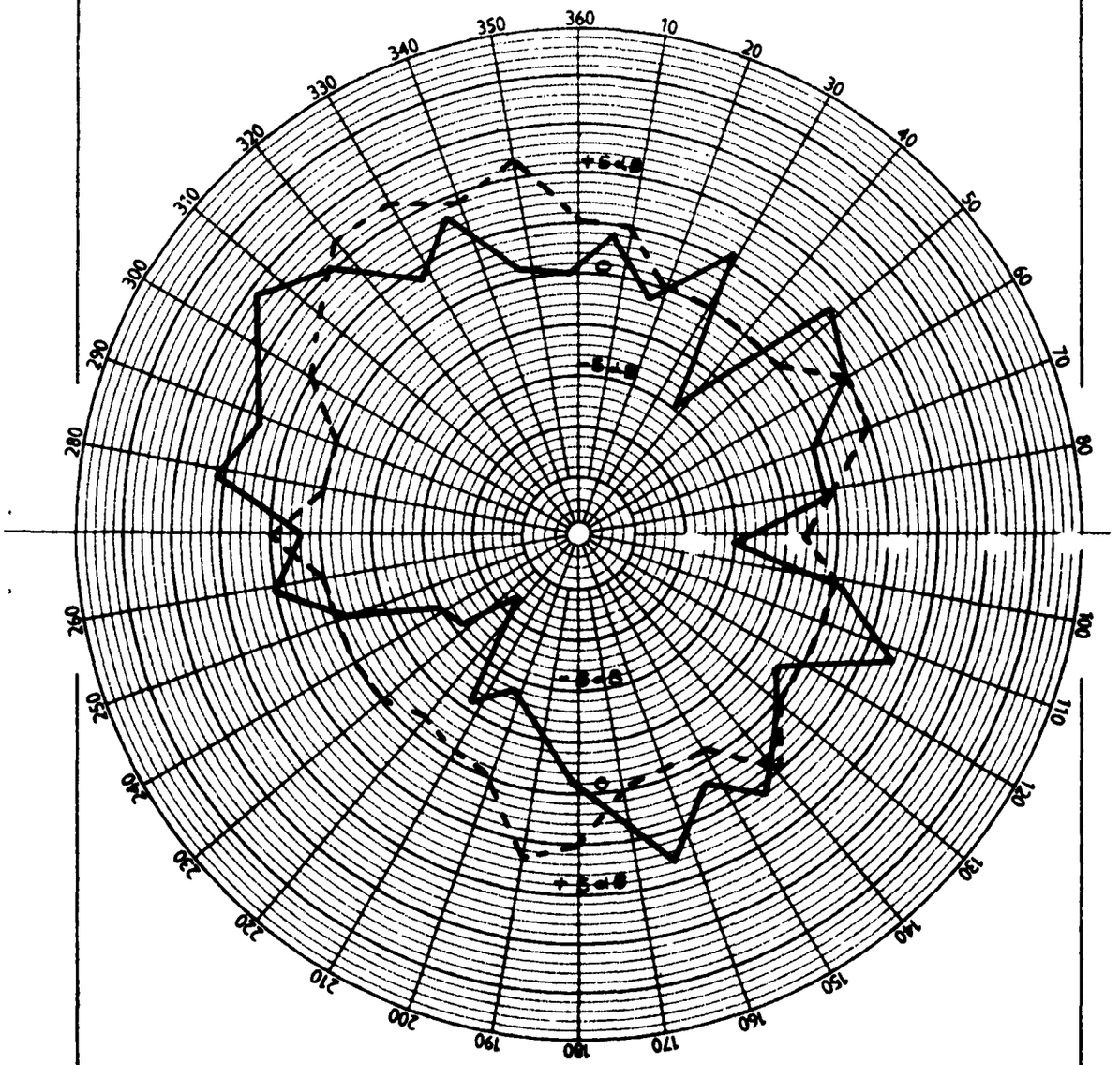
FIG. 4.

FREQUENCY:- 132·0 Mc/s.
DISTANCE FROM BASE:- XN 816 - 23 N.M., XR 105 - 78 N.M.
HEIGHT ABOVE BASE:- XN 816 - 2,100 FT., XR 105 - 8,000 FT.
AIRCRAFT:- TYPE:- ARGOSY C.MK.1.
Nº:- XR 105 & XN 816.
DATE:- XN 816 - 25·9·61, XR 105 - 2·1·64.
A.R.I:- 23088.



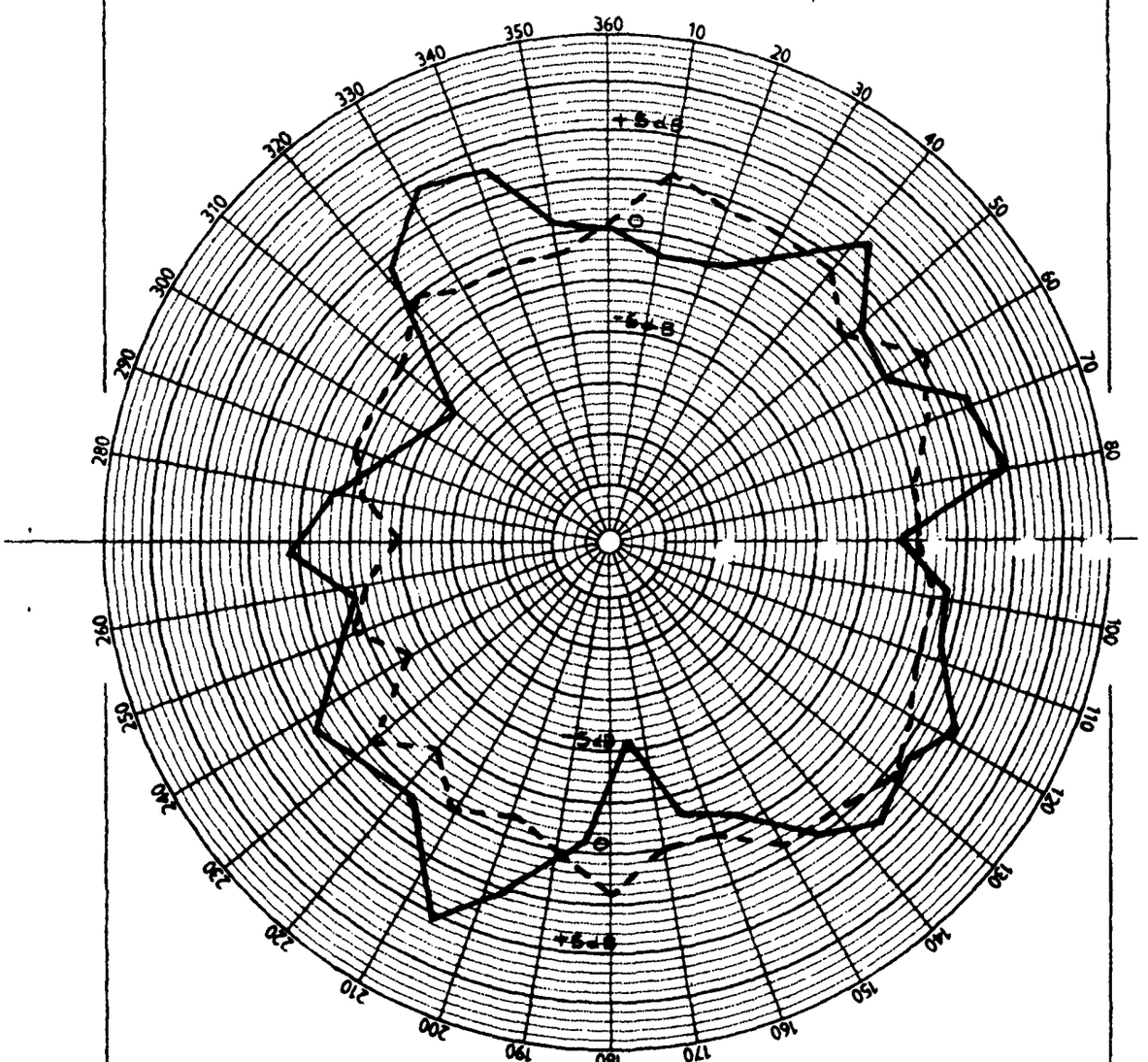
——— ARGOSY XR 105 CARRYING STORES.
— — ARGOSY XN 816 'CLEAN.'

EFFECT OF EXTERNAL STORES ON V.H.F. POLAR DIAGRAM (Nº 2 V.H.F.)

14TH. PART OF | 936 | SK. 8. 9458

FIG. 5.

FREQUENCY:- 236·1 Mc/s
DISTANCE FROM BASE:- XN 816 - 23 N.M., XR 105 - 40 N.M.
HEIGHT ABOVE BASE:- XN 816 - 2,100 FT., XR 105 - 4,000 FT.
AIRCRAFT:- TYPE:- ARGOSY C. MK.1.
Nos. - XN 816 & XR 105.
DATE:- XN 816 - 25·9·61, XR 105 - 28·11·63.
A.R.I.:- 18124/1.



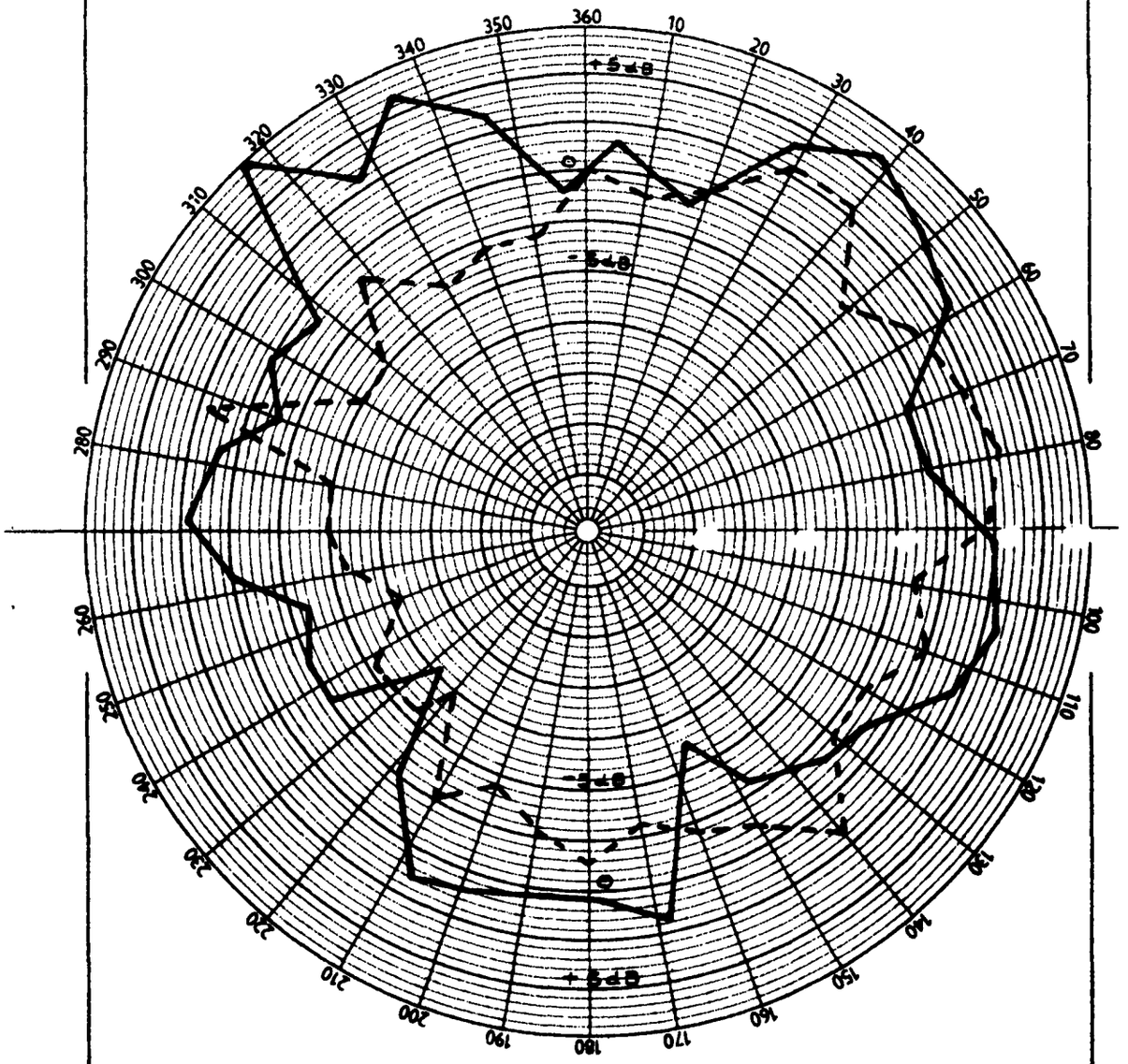
——— ARGOSY XR 105 CARRYING STORES.
— — ARGOSY XN 816 'CLEAN.'

EFFECT OF EXTERNAL STORES ON U.H.F. POLAR DIAGRAM.
(LOWER AERIAL)

14TH PART OF 936 SK. 8. 3459

FIG. 6.

FREQUENCY:- 305·5 M°/s.
DISTANCE FROM BASE:- XN 816 - 23 N.M., XR 105 - 40 N.M.
HEIGHT ABOVE BASE:- XN 816 - 2,100 FT., XR 105 - 6,000 FT.
AIRCRAFT:- TYPE:- ARGOSY C.MK.1.
N°:- XR 105 & XN 816.
DATE:- XN 816 - 28·9·61, XR 105 - 31·12·63.
A.R.I.:- 18124/1



——— ARGOSY XR 105 CARRYING STORES.
— — ARGOSY XN 816 'CLEAN.'

EFFECT OF EXTERNAL STORES ON U.H.F. POLAR DIAGRAM.
(LOWER AERIAL)

FREQUENCY:- 395·8 M²/s.

DISTANCE FROM BASE:- XN 816 - 23 N.M, XR 105 - 40 N.M.

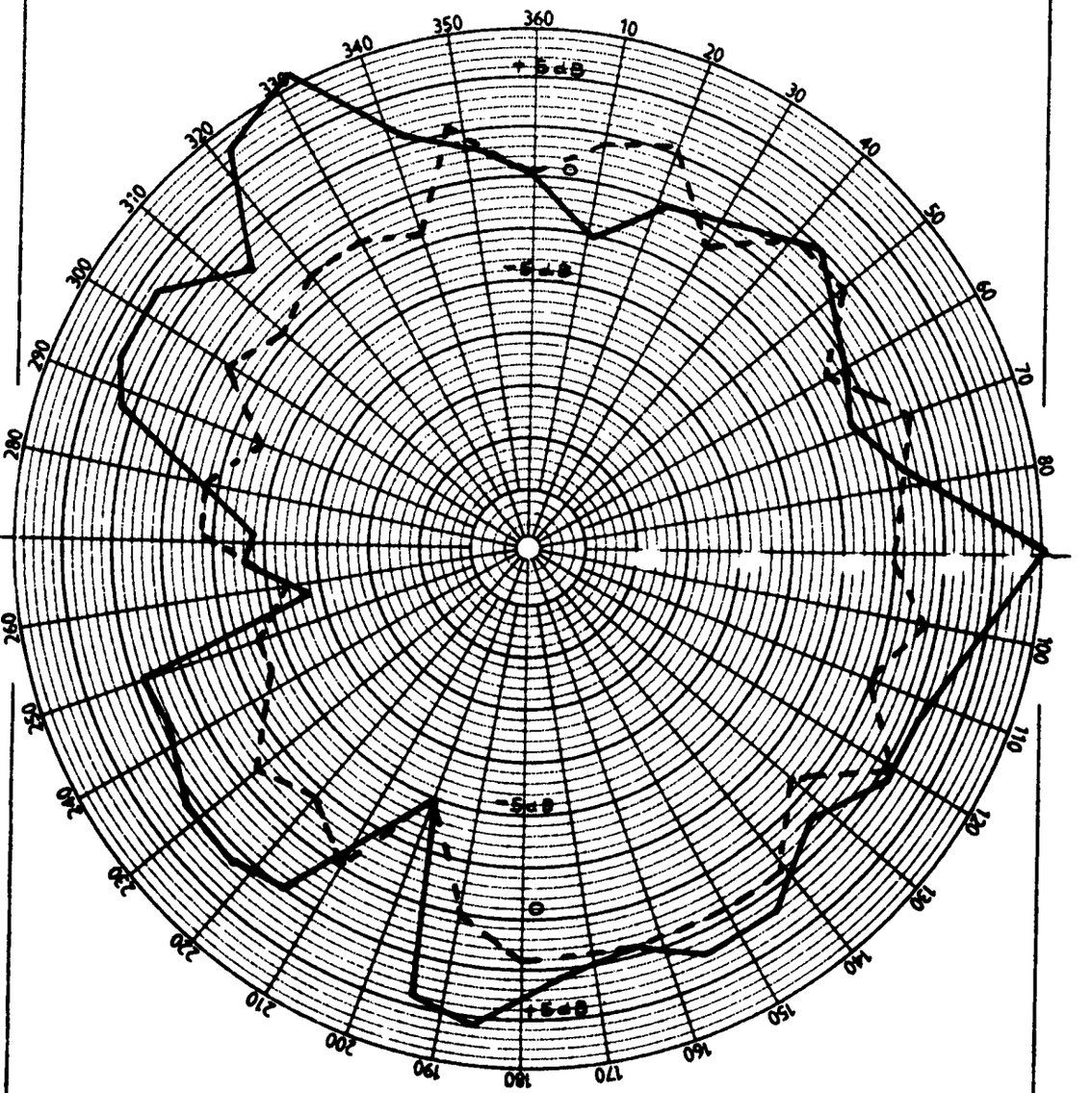
HEIGHT ABOVE BASE:- XN 816 - 2,100 FT., XR 105 - 6,000 FT.

AIRCRAFT:- TYPE:- ARGOSY C. MK.1.
Nº:- XR 105 & XN 816.

DATE:- XN 816 - 25·9 ·61, XR 105 - 31·12·63.

A.R.I:- 18124/1

FIG. 7.



——— ARGOSY XR 105 CARRYING STORES.
— — ARGOSY XN 816 'CLEAN'

EFFECT OF EXTERNAL STORES ON U.H.F. POLAR DIAGRAM.
(LOWER AERIAL)

14TH PART OF 936 | SK.B. 3461

SKB 3462	14TH PART OF REPORT Nº A&AEE/936	ARGOSY C MK I XR105 & XN816	TR & J.H.	CH. MR. WITHERS	APP [illegible]	29 7-65

AIR SWING OF RADIO COMPASS AD 712 (A.D.F. Nº2)

FREQUENCY 370 KC/S
HEIGHT 1200 FT A.G.L
---- ACCEPTABLE LIMITS

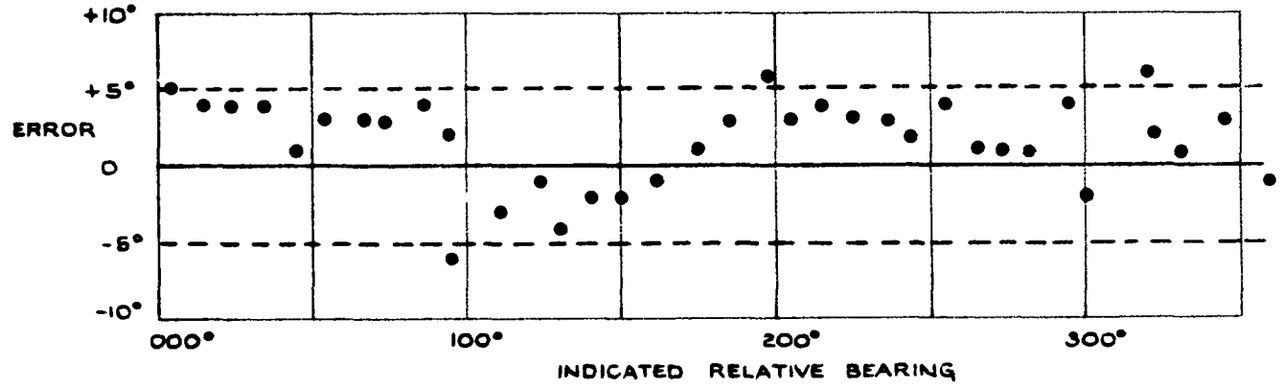
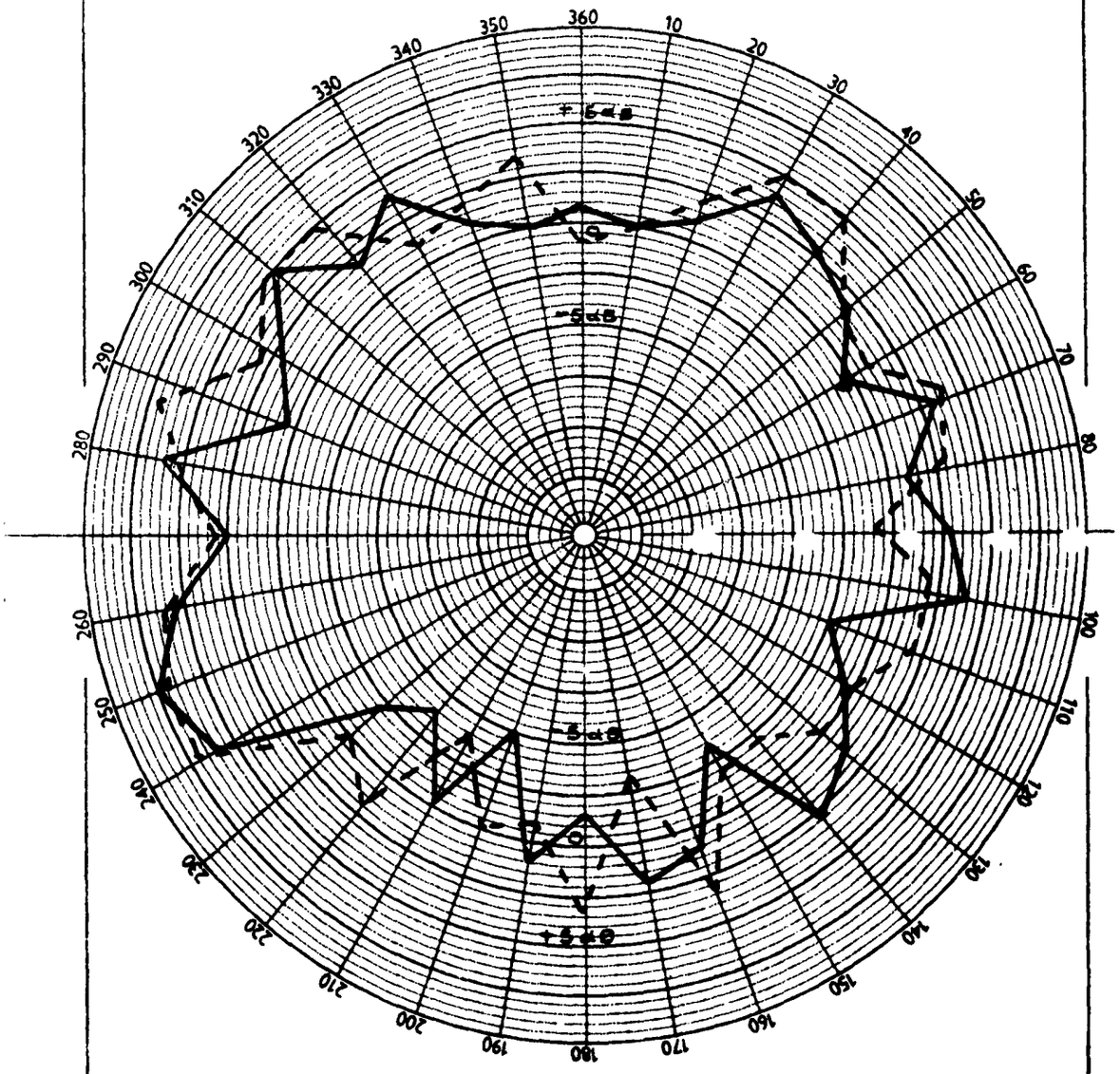


FIG. 8.

FIG. 9.

FREQUENCY:- 1,090 Mc/s.
DISTANCE FROM BASE:- 23 NAUTICAL MILES.
HEIGHT ABOVE BASE:- 2,100 FT.
AIRCRAFT:- TYPE:- ARGOSY C. MK.1.
Nº:- XR 105 & XN 816.
DATE:- XN 816 - 28·9·61, XR 105 - 8·5·64.
A.R.I.:- 5848.



——— ARGOSY XR 105 CARRYING STORES.
— — ARGOSY XN 816 'CLEAN.'

EFFECT OF EXTERNAL STORES ON I.F.F. 10. POLAR DIAGRAM.
(LOWER AERIAL)

14TH. PART OF 936 SK. B. 3463

SK 5.3464	14TH PART OF REPORT No A.&A.E.E./936	ARGOSY C MK.1 XR105 & XN816	TR S.J.H.	CH. MR. WITHERS	APP. R.W.J. for S of N.R	29-7-65

DIAGRAMMATIC SKETCH OF I.F.F.10 AERIAL FEEDER CIRCUIT.

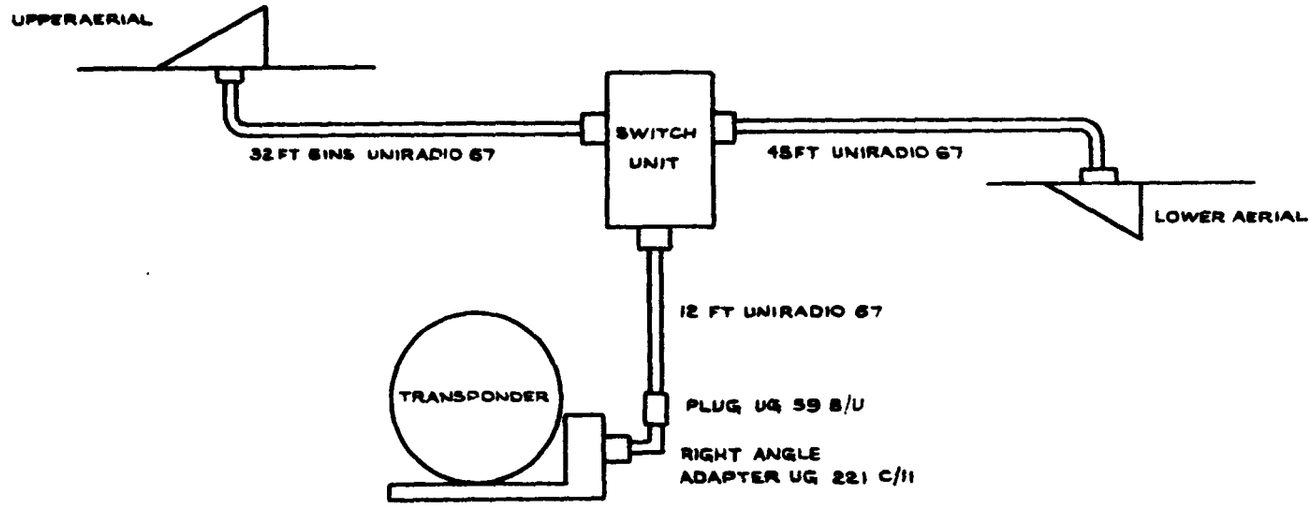


FIG. 10.

[dstl]

Information Centre
Knowledge Services
[dstl] Porton Down,
Salisbury
Wilts
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